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## ELECTRICAL STIMULUS AND RESPONSE.

*Response in the Living and Non-Living.* By Jagadis Chunder Bose, M.A. (Cantab.), D.Sc. (Lond.). Pp. xix + 199; with illustrations. (London: Longmans, Green and Co., 1902.) Price 10*s.* 6*d.*

THE apparent aim of this book is to show that "living response in all its diverse manifestations is found to be only a repetition of responses seen in the inorganic" (p. 189). It is difficult to treat this conclusion seriously, and the difficulty is sensibly increased by the mental bewilderment which is experienced on reading such statements as the following :—

"From a confusion of 'dead' things with inanimate matter it has been tacitly assumed that inorganic substances, like dead animal tissues, must necessarily be irresponsive, or incapable of being excited by stimulus—an assumption which has been shown to be gratuitous" (p. 181).

The conclusion which we are compelled to draw from this quotation is that Prof. Bose does not regard dead things as inanimate matter, and if this be the case, it may seem superfluous to offer any extended criticism of those portions of the book which set forth the experimental grounds for such beliefs. It is, however, very desirable that discredit should not be thrown upon the use of fruitful methods of investigation well known to physiologists in consequence of the fallacious character of the author's conclusions; moreover, the experiments upon which he rests his case are set forth in a somewhat convincing manner, and the book may with the aid of copious illustrations achieve some popularity.

The experimental facts brought forward comprise, (1) some limited aspects of the changes occurring in muscles, nerves and plants when subjected to particular modes of stimulation, and (2) some electrolytic effects occurring when moist conductors are brought into contact with metallic surfaces and the latter are caused to vibrate. It is on the strength of a superficial resemblance between the electromotive changes observed in these two groups that the author makes his astounding generalisations. The phenomena of muscle and nerve brought forward are taken from various physiological works, and the particular response selected is that of the familiar excitatory electromotive change; it is, however, very inadequately treated, as no reference is made to the classical researches of Du Bois-Reymond, Hermann, Bernstein, Hering, Burdon Sanderson and others.

In consequence of the author's limited survey of the subject, he has fallen into an error of quite an elementary nature in his description of the muscular response. He appears to think that the superficial resemblance between the change of form which muscle undergoes in contraction and the swing of a galvanometer needle when deflected by the sum of the electrical currents present in tetanised muscle affords sufficient ground for the statement that "it is found that the electrical and mechanical records are practically identical" (p. 12). This identity can only refer to the time relations of the two classes of events, and it has been known for half a century that the electrical and mechanical responses do not run the same course. The results obtained by the physiological rheoscope, the repeating rheotome, the telephone and the capillary electrometer (all disregarded by the author) afford convincing proof that whereas the change of form during so-called tetanus is sustained by the fusion of the successive mechanical responses, the electrical disturbances are not so fused, but constitute a rhythmical series of distinct states. The time relations of the muscular twitch evoked by a single stimulus reveal the reason for this want of parallelism, since the electrical response has both culminated and subsided before the mechanical one has been completed. The author having thus disregarded the most fundamental characters of muscular and nervous responses, *i.e.* their time relations, it is clear that no sweeping generalisations involving these responses are justifiable.

In treating the vegetable tissues, the author has selected as a typical response an electrical change which occurs in portions of plants which have been subjected to sudden mechanical strain (torsion, &c.). The displacement caused by the strain is associated with a difference of electrical potential in the part primarily affected as compared with other parts situated in more remote, and thus less disturbed, regions. These electrical alterations are of considerable interest, and attention has been drawn to their existence by Waller, who has pointed out their local character. The local character of the electromotive effect has its counterpart in animal tissues, but it is not characteristic of those particular animal responses which are selected by the author for the purpose of comparison, since these are propagated from the seat of stimulation along the protoplasmic continuum of the muscle or the nerve fibres. Propagated effects of this type can be found in certain plant tissues—for instance, Dionæa—but the plant responses described by Prof. Bose do not include these. It follows, therefore, that such comparisons as the author is able to make do not warrant the sweeping statement that

"a complete parallelism may be held to have been established between plant response on the one hand and that of animal tissue on the other" (p. 80).

Some curious chapters in the book deal with a novel "response in metals." This was generally obtained by connecting a strip of metal (tin, platinum, &c.) with moist conductors, which in their turn were connected with a galvanometer through non-polarisable junctions; the sudden jar of a blow was the so-called stimulus, and the alterations caused by the shatter in the polarisation interfaces appear to constitute the so-called electrical response. The observations are brought forward by Prof. Bose, not so much for any intrinsic physical interest they may possess, as for the purpose of showing how far they are susceptible of modification under conditions which, in his opinion, also modify the electromotive phenomena of living tissues and thus of serving as a support for his speculations. The language employed in their description is often of a singular character; thus

we are told that "tin is practically indefatigable" (p. 118), that

"we may thus, by reducing or abolishing the excitability of one end by means of suitable chemical reagents (so-called method of injury) obtain response in metals" (p. 87),

and many other phrases borrowed from physiologists occur plentifully in the text. The use of such terminology appears in itself to indicate the unconscious bias of the author towards the conclusion he has in view.

In later chapters of the work, a series of apparent resemblances between the retinal currents described by physiologists and photoelectrolytic changes in sensitised metal plates leads the author to the amazing assertion that

"there is not a single phenomenon in the responses, normal and abnormal, of the retina which has not its counterpart in the sensitive cell constructed of inorganic material" (p. 169).

After this, we are incapable of being further surprised, even by the confident prediction that

"the parallelism will thus be found complete in every detail between the phenomena of response in the organic and inorganic" (p. 147).

We are all aware that living processes, apart from the evidence of our own consciousness, can only reveal themselves as physical and chemical changes; among these are the electromotive effects in living tissues which afford one aspect of those subtle and complex physico-chemical relationships comprised under the term metabolism. The play and nature of this metabolism constitute for most of us the fundamental mystery of life; but to Prof. Bose the living response presents "no element of mystery" (p. 189). Metabolism, with its phases of assimilation and dissimilation, has for him no significance, and he characterises all correlations of electromotive change with metabolic process as arbitrary and unnecessary assumptions (p. 126). Even the connection of fatigue in animal tissues with the dissimilation products of activity has, he says, long been seen to be an inadequate explanation. He admits that "the criterion by which vital response is differentiated is its abolition by the action of certain reagents" (p. 188), yet he declares that metals can be "transformed from a responsive to an irresponsive condition by the action of similar poisonous reagents" (p. 188). We are bewildered by this apparent inconsistency, and are thankful to reflect upon such statements as he does not make. Among these, the most consoling is that of the re-creation of a living tissue; it is clear that although the metallic combination may be turned backwards and forwards through responsive and irresponsive stages, there is no such retransformation of the living tissues when once these have become what Prof. Bose calls "dead things." This should give him pause in his prediction that the reader will find that parallelism *complete in every detail* which, upon the strength of specious and partial resemblances, he claims to have established between the behaviour of materials living and non-living. F. G.

## THE LEAD ACCUMULATOR.

*Secondary Batteries: their Theory, Construction, and Use.* By E. J. Wade. Pp. ix+492. (London: The *Electrician* Printing and Publishing Co., Ltd.) Price 10*s.* 6*d.* net.

MR. SWINBURNE in his presidential address to the Institution of Electrical Engineers remarked that it was wonderful that we had the lead cell at all, seeing that we owed it to a chance observation of Planté. On a perusal of Mr. Wade's book it seems even more remarkable that the "chance observation of Planté" has been developed into so indispensable an adjunct of electrical engineering. It is usually the boast of the electrical engineer that his branch of engineering can lay claim to being an exact science in the truest sense. He is able to base on a solid foundation of theory the design of a 4000 H.P. alternator or a sensitive millivoltmeter, and feel confident that the result will be what he requires. He can work contentedly with these things, because he feels that he knows to what their behaviour under different conditions is due. But with the accumulator it is different. Probably nine electrical engineers out of ten do not know what is the cause of the E.M.F. given by the combination lead / sulphuric acid / lead peroxide, but imagine that, like Topsy, "it just growed." Still less would they be able to give any plausible explanation of the frequently erratic behaviour of accumulators. This is partly due to a narrow-minded contempt for chemistry, more or less inherent in the electrical engineer in his student days, and only regretted when the time for studying first principles is past. But the ignorance must be also partly ascribed to the unsatisfactory condition of the knowledge amongst experts in the subject.

These circumstances make Mr. Wade's book all the more welcome. The author has endeavoured to set forth all that is known concerning the storage battery, and great credit is due to him for the very thorough way in which he has carried out his task. After a brief introductory chapter, the author passes to the history of the lead cell; it is noteworthy that this chapter practically resolves itself into a history of the development of the "grid" or other support for the active material, so slight is the alteration that has been made from the chemical side since the time of Planté and Faure. The tenth and final chapter, in which are described all the leading makes of cells, whether of English, continental or American manufacture, is marked by the same characteristic.

The seventh, eighth and ninth chapters deal with the manufacture, testing and use of lead cells, and these will be found very instructive, especially by those interested in the commercial application of the storage battery. In the eighth chapter the author has attempted to define the lines on which lead cells should be designed; the result is not very satisfactory, but the fault does not lie with Mr. Wade. Until theory has shown the way, design must necessarily be carried out on empirical lines, and reliance must be placed on intuitive perception of what is good and what bad. In chapter iii. Mr. Wade discusses storage cells